THE EARLY INFLUENCE OF W. EDWARDS DEMING ON THE DEVELOPMENT OF STATISTICAL QUALITY CONTROL IN THE UNITED STATES AND IN JAPAN

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The first time that I heard a detailed account of W. Edwards Deming's early experiences with quality control, I was in Washington to attend an "International Conference on Fatigue Failure of Engineering Structures" and to give a paper there. It was 1969 and the 69th year of his life.

Some time before the conference, I received an invitation to join Dr. Deming and another conference speaker who was from the University of Lisbon. The invitation was for dinner at the Cosmos Club on the first evening of the event. I accepted with some feeling of anticipation, and then when I arrived in town, touched base by phone to find when I should meet them for the occasion.

At that time I discovered two problems concerning my projected fellow dinner guest. First, he was not the Portuguese professor whom Ed Deming had met some years before, but a younger man with the same unusual last name. Second, he had stopped in New York, on his way to Washington

from Portugal, to consult with a co-investigator at Columbia University; had thereupon contracted food poisoning, or perhaps stomach flu; and had rushed back home to Lisbon to seek treatment or comfort or both. He didn't make it to the conference, though he did later submit a paper for the published proceedings.

So, it didn't matter that this was the wrong man; he didn't come to dinner anyhow. That left the two of us to eat and converse, once we met in the Ladies' Parlor, just inside the ladies' entrance to the Cosmos Club. (In those days, my consciousness of male chauvinism was languishing comfortably, yet to be raised, so I paid little attention to this quaint arrangement.) I might add that the ladies' entrance is still there at the Cosmos Club, but its use has been abandoned for reasons of security.

Mealtime provided a chance for me to find out how W.Edwards Deming, who was originally trained in mathematics and physics, had made such an impact on the discipline of statistical quality control and had had so much infuence in its application in this country and in Japan.

Recently, I have refreshed my memory and filled in details in conversations with him during several Saturday and Sunday afternoons in his home-based ofrice in Washington. These took place between his trips to South Africa, British Columbia, the Netherlands, Japan, Korea and most of the major and many of the minor cities of the United States. I have also been aided in the following by documentation provided (directly or indirectly) by Churchill Eisenhart, Allen Wallis, Holbrook Working and THE MAINICHI DAILY NEWS of Tokyo, the issue of November 10, 1965.

It's useful to begin the story in March of 1938, shortly before the time

Ed Deming left his position as a mathematical physicist at the U. S. Department of Agriculture (USDA) to join the U.S. Census Bureau. At that time, he arranged for Dr. Walter Shewhart of the Bell Telephone Laboratories to deliver a series of four lectures on "Statistical Method from the Viewpoint of Quality Control" at the USDA Graduate School. These lectures were published by the Graduate School in 1939 "with the editorial assistance of W. Edwards Deming".

Shewhart, in his 1931 book, "Economic Control of Quality of Manufactured Product," had given his criteria for determining whether a given set of numerical data was in a state of statistical control -- and had given also the particulars of his corresponding control-chart techniques.

In a 1981 interview published in MILITARY SCIENCE AND TECHNOLOGY, Volume 1, Issue No. 3, Ed Deming discussed Shewhart's important contribution.

> "Dr. Shewhart first saw the fact that random variation represents the ultimate state of a system, that when you have achieved that state, then you have an identifiable process, and until then you do not -- you have chaos in a small degree or to a high degree.
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> "Causes of nonrandom variation are called assignable causes or special causes. And those are usually chargeable to particular, local conditions that the workers can recognize and eliminate. And then you have left random variation that defines the system, and from then on only the management can improve it. That was Shewhart's great contribution."

In his first book, Shewhart was concerned with the application of his

methods and techniques in controlling the quality of industrial production processes. In the USDA lectures and the book derived from them, however, he not only reviewed his earlier work and the developments during the intervening years, but also devoted one full lecture (chapter) to their application to the results of measurement of physical properties and constants, and one lecture (chapter) to the "specification of accuracy and precision" of measurement processes generally.

The editing of the Shewhart book, along with earlier work with Harold Dodge at Bell Labs and Captain Leslie Simon (later Lt. General) at Aberdeen Proving Ground, had a profound effect on W. Edwards Deming. The ideas that resulted from this exposure are central to his total philosophy of dealing with problems of production.

He first made use of the material in the two chapters in the Shewhart book on measurement and precision in consulting he did some few years later for the U.S War Department during World War II. Shewhart's general theory, however, he applied shortly after he became familiar with it. This is explained by Dr. Churchill Eisenhart, Senior Research Fellow at the National Bureau of Standards, in notes he wrote recently on Deming accomplishments. The notes were to be read on the occasion of the presentation of a fourth honorary doctorate to Dr. Deming, this by the University of Maryland on January 8, 1983. Many of the facts were obtained from "Revolution in U.S. Government Statistics, 1926 - 1976," a 1978 U.S. Government Printing Office publication by Joseph Duncan and William Shelton.

> "In neither of his books, nor in his other related publications, did Shewhart mention or hint that his statistical quality control procedures

could be applied equally well to routine clerical operations, with comparable beneficial effect. This is obvious once one thinks of it, and think of it Deming did. Statistical quality control procedures were applied, at his suggestion, in the clerical operations of the 1940 population census, for example in the coding and card-punching operations. The procedure worked very well. During the learning period, the error rate of a card puncher was high; but with training and experience, a good card puncher's error rate dropped markedly and exhibited statistical control at a low level. At first, the work of all card punchers received 100% verification or correction. Later 39% qualified for only sample verification.

"Work subject only to sample verification flowed through the process six times faster than otherwise. Deming and Leon Geoffrey, in an article in the September 1941 issue of the JOURNAL OF THE AMERICAN STATISTICAL ASSOCIATION, estimated that the introduction of quality control saved the Bureau $263,000, which was transferred to other work, and also contributed to earlier publication. Use of statistical quality control procedures has been a standard practice at the Bureau of the Census ever since."

The next relevant scenario began early in 1942, soon after war was declared against the United States by Japan, Germany, Italy, and their allies. By then Ed Deming was well established at the Census Bureau, but was also working half time as Consultant to the Secretary of War. Recent Wilks Award winner, W. Allen Wallis, now Undersecretary of State for Economic Affairs and then on the faculty of Stanford University, tells of those times in the June 1980 issue of the JOURNAL OF THE AMERICAN

"The atmosphere there that spring was satirized by a squib in the student paper saying, 'It is rumored that in the outside world there is a war and a shortage of Coca Cola.' As one of several statisticians - Holbrook Working, Eugene Grant, Quinn McNemar, Harold Bacon - seeking some way that we at Stanford could contribute to the war effort, I wrote on April 17, 1942, to a friend in Washington, W. Edwards Deming of the Census Bureau, that 'those of us teaching statistics in various departments here are trying to work out a curriculum adapted to the immediate statistical requirements of the war. It seems probable that a good many students with research training might by training in statistics become more useful for war than in their present work, or might increase their usefulness within their present fields.....'

"Deming responded on April 24 with four single-spaced pages on the letterhead of the Chief of Ordnance, War Department. After some explanatory background on the theme that, 'the only useful function of a statistician is to make predictions, and thus to provide a basis for action', he wrote:

"'Here is my idea. Time and materials are at a premium, and there is no time to be lost. There is no royal short cut to producing a highly trained statistician, but I do firmly believe that the most important principles of application can be expounded in a very short time to engineers and others. I have done it and have seen it done. You could accomplish a great deal by holding a school in the Shewhart methods some time in the near future. I would suggest a concentrated

effort -- a short course followed by a long course. The short course would be a two-day sesson for executives and industrial people who want to find out some of the main principles and advantages of a statistical program in industry. It would be a sort of popularization, four lectures by noted industrial people who have seen statistical methods used and can point out some of their advantages. The long course would extend over a period of weeks, or, if given evenings, over a longer period. It would be attended by the people who actually intend to use statistical methods on the job. In many cases they would be delegated by the men who had attended the short course.'

"'I would suggest that both courses be thrown open to engineers, inspectors, and industrial people with or without mathematical and statistical training. Naturally, any person who has had considerable statistical training would be in a position to get much more out of the course, but few would be in this fortunate position...'

"On May 1, I was able to write Deming that, 'Your letter arrived a few hours ago...The specific suggestions struck home so well that Holbrook Working (Chairman of the University Committee on Statistics) has already talked with two or three of the key people and arranged a general meeting of everyone in statistics'; on May 21 the first letter about the course went to firms supplying Army ordnance in the western region; and the first course was given in July 1942 at Stanford."

A short article by Holbrook Working, published in SCIENCE in November, 1942 describes this effort. Working, after some preliminaries and his description of the Deming letter, went on as follows.

"The suggestion posed two problems: that of providing for the requisite instruction, and that of bringing to the course men actually in a position to apply the methods.

"Suitable machinery for organizing and financing the suggested course was already in existence in the engineering science and management War Training Program, financed by the Office of Education. The institutional director of the program at Stanford took up the plan with enthusiasm. Aided by active support from the Ordnance Department, through its San Francisco District Office, he was able to bring together, in early July, less than six weeks after the original suggestion had been received, a group of twenty-nine key men from industries holding war contracts and from procurement agencies of various branches of the armed services. These men, with three others, entered upon an intensive ten-day course with classes running eight hours a day. All thirty-two men completed the course."

Dr. Working went on to describe a second course, offered in Los Angeles in September, 1942, and then discussed the personnel involved in the instruction.

"Two Professors, Eugene L. Grant and Holbrook Working from different departments of Stanford University and Dr. W. Edwards Deming from the Census Bureau worked together in each course. A fourth man on the staff for each course was drawn from industry to present the point of view of a man meeting, from day to day, the practical problems of applying the methods under discussion.

Dr. Churchill Eisenhart, in his notes on Deming accomplishments, describes subsequent events.

> "The course was such a success that early in 1943, Working was chosen to head the now famous major national program that put on intensive 8-day courses in statistical quality control throughout the country, under the auspices of the Office of Production Research and Development of the U.S. Office of Education. Deming was the teacher of 23 of these courses. By March 1945, they had been attended by more than 1900 persons from 678 industrial concerns in the United States and 13 in Canada. Many of the 'students' in the earlier of these went out to serve as 'instructors' in part-time courses that brought the message to an additional 31,000 persons in American and Canadian industry, and 2500 persons attended other part-time courses in statistical quality control. The program had an enormously beneficial effect on the quality and volume of American and Canadian war production; and 'prepared the soil' for the establishment of the American Society for Quality Control (ASQC) in February 1946, in the founding of which Deming also played an important role."

Ed Deming agrees that he did, indeed, play an important role in the founding of the ASQC.

> "Wherever I taught I told the people, 'Nothing will happen if you don't keep working together. And you've learned only a little. I know only a little. You must keep on working and meeting together. Get someone to send out postal cards, and persuade someone to let you use a room for an evening.' And they did it. It was that nucleus upon which congealed the ASQC."

In the 1981 MILITARY SCIENCE AND TECHNOLOGY interview, Ed Deming stated in a few words the principal reason that the brilliant successes in using statistical quality control methodology to increase quality and productivity, later to be exhibited on a grand scale in Japan, were not realized in this country.

> "The courses were well received by engineers, but management paid no attention to them. Management did not understand that they had to get behind quality control and carry out their obligations from the top down."

In our recent conversations, he expanded on this theme, discussing first the random variation that defines a process, a manufacturing process, say, in an industrial setting.

> "In the wartime courses we taught people that there is variation in all things and that the readings that one takes from a manufacturing process must exhibit stable randomness, or they don't have any meaning as far as defining the process. Any instabilities can help to point out specific times or locations of local problems. Once these local problems are removed, then there is a process that will persist until somebody changes it.
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> "Changing the process is management's responsibility. And that we failed to teach. Professor Working thought that it would be a good idea to include management in the courses, so we devoted one afternoon to letting the people bring their management. Well, some did come, but most did not. And I don't think we had anything wonderful

to tell them. We had no stories to tell them.

"By 1950, these simple methods that we had taught were working all right, but nothing astounding happened. Not that they weren't accomplishing something, but it was only a small part of what could be accomplished. The big gains come from changes in the system, the responsibility of management.

In Japan, management did take responsibility for putting statistical quality control methods to work. The story of how that happened begins in 1946. In that year, Dr. Deming made a trip around the world under the auspices of the Economic and Scientific Section of the U.S. Department of War. While he was in India, working with Mahalanobis, the famous Indian statistician who had founded the prestigious Indian Statistical Institute, he got orders to continue on to Japan. He described those times to me.

"I stayed in Japan for two months to assist with studies of nutrition, agricultural production, housing, fisheries, etc. In that way I became friends with and learned from some of the great Japanese statisticians. Statistics was well established in Japan."

He is not aware of how there came to be so many learned statisticians in Japan those many years ago, but he remembered that a Dr. Seito had been studying statistics at University College in London when he was there a few years earlier.

"In 1948, I went again to Japan, this time for the Department of Defense, to do more of what I had done before. I made an effort to talk whenever possible with Japanese statisticians. I would go to the Post Exchange, where I had privileges, and buy food. Then I would

lug it to the Army operated Dai-Ichi Hotel where I had a very small room. If I said it was 8 feet by 9 feet, I wouldn't be far off. Then I would arrange for a private dining room in the hotel and serve the food to my Japanese friends.

"Any food tasted good to them, I'm sure. We'd sit around the table and talk. I had no vision of what was to happen. I just told them that they were important to the country in the reconstruction of Japan. This idea was new to them.

"Now, there is a sub-plot involving a Mr. Ken-ichi Koyanagi, who had earlier been in jail for 8 years -- ostensibly for being a Communist. Whether he had been under house arrest or actually in jail, I don't know. Probably all there was to it was that he had a mind of his own and wouldn't go along with the war lords. I say this because when it came time for him to get a visa later to come to this country, there was no great problem.

"His major in the university was German literature. Most people who rise in management in Japan never have studied Management Science, thank goodness. It's better that they don't.

"In 1947 he formed the Union of Japanese Scientists and Engineers (JUSE) consisting then of about 7 men, their purpose being the reconstruction of Japan. Mr. Koyanagi held the group together. And Dr. Nishibori, who was in the original group and later Chairman of Japan's equivalent of our Atomic Energy Commission, told me that they had nothing much to talk about. They would just eat and drink. Suddenly one night, Dr. Nishibori had the bright idea that statistical

methods could help in the reconstruction of Japan. This would be a way of helping that wouldn't require new equipment, which they had no means of obtaining.

"One of the principal problems of Japanese industry at that time was that the captive markets of China and Korea that they had had prior to the war, were now lost to them. And they needed to trade so that they could import food.

"Came in 1949 a letter asking me to teach statistical methods in industry. I couldn't go at that time, though I wished to. I had too many projects going, so I kept stalling. I finally did go in June of 1950 under the auspices of the Supreme Commander of Alled Powers."

THE MAINICHI DAILY NEWS OF TOKYO, on the occasion of the presentation of the Deming prizes on November 10, 1965, described the visit and the conditions in Japan immediately following the war.

"The scholastic contact between Japan and Dr. Deming dated back to April 1950 when Ken-ichi Koyanagi managing director of the JUSE, wrote to Dr. Deming, then in the U.S. asking for lectures on statistical quality control when he visited Japan later in the year. He readily accepted the plea.

"At that time, few Japanese realized the significance of quality control. In the prewar years, there were, indeed, some Japanese scholars and engineers who were engaged in the study of quality control, and some of them attempted to put it into practice. But no company dared to carry out the wholesale introduction of the revolutionary idea.

"After the war, the nation's industry was quick to rise again, but the quality of its products were all but inferior. Faced with enormous demand, manufacturers were all busy in turning out as many products as possible, and no one cared about quality.

"The concept of quality control made inroads into the Japanese industries in the form of an Occupation Forces order to communication equipment manufacturers. When they started to employ the modern production formula, some private organizations paid a deep concern. Soon they stepped into the field and started dissemination activities.

"Independent from these organizations, the JUSE also launched an educational service of quality control in 1948. A series of lectures was sponsored on the subject of statistical analysis of small samples. Several Japanese experts gathered to form a research group, primarily aimed at collecting necessary literature. But these activities had a discouraging result: there was little experience and material available. Still under occupation, Japan was in no position to obtain enough literature and material related to quality control.

"Then came the offer from Dr. Deming to the joy and surprise of all the people concerned. In his first lecture meeting in Tokyo in mid-1950, 230 scholars and statisticians gathered, impressed by the exciting concept of statistical quality control uttered by the U.S. scholar. In another lecture meeting in Fukuoka, 110 were present.

"Dr. Deming called on the students to come out of their studies and, with courage and confidence, go into factories, to keep contact

with, and teach, business managers and engineers, and to promote their theoretical research on the application of statistical methods"

He recalls:

"I lectured in English, but I had a wonderful translator, Mr. Hisamachi Kano. His father was a banker, and as a child, he lived in New York, London and Paris, so he learned English and French as he was growing up. He probably learned Japanese at home."

"His English was absolutely perfect, with every kind of idiom. I was very fortunate because I had him with me for the duration of every visit for a period of over ten years.

Dr. Deming described to me the fateful events that involved Japanese higher management in the educational process and provided the critical impetus for changing the image of Japanese products.

"They were wonderful students, but on the first day of the lectures a horrible thought came to me, 'Nothing will happen in Japan; it'll be a farce unless I talk to top management.' By that time I had some idea of what top management must do. There are many duties to be performed that only the top people can do: consumer research for example, work with vendors just for example. I knew that I must reach top management. Otherwise it would just be another flop as it was in the states.

I immediately talked to American friends who knew the right Japanese and before long, I was talking to Mr. Icharo Ishikawa, who had formed the great Kei-dan-ren, the Japanese association of top

management.

"I had 3 sessions with Mr. Ishikawa; and at the end of the third session, he understood what I needed to do. He sent telegrams to the 45 or so top level men to come to the Industry Club the next Tuesday at 5 o'clock to hear Dr. Deming. And they all came.

"I did the best I could. I gave them encouragement. That was the main thing. I told them that they could produce quality for the consumer, partly industrial, partly household, for the Western world, in return for food. Conditions were such that they would have to do that.

"They thought that they could not because they had such a terrible reputation when it came to quality. But they knew what good quality was. Ask anybody in our Navy, and they'll tell you that. What they made for military purposes was superb. But for consumer goods, they'd never tried. They didn't know what it was to stand back of any goods. At that time a Japanese item wouldn't last very long; there was no endurance.

"I told them, 'Those days are over. You can produce quality. You have a method for doing it. You've learned what quality is. You must carry out consumer research, look toward the future and produce goods that will have a market years from now and stay in business. You have to do it to eat. You can send quality out and get food back. The city of Chicago does it. The people of Chicago do not produce their own food. They make things and ship them out. Switzerland does not produce all their own food, nor does England.'"

"Incoming materials were terrible, off gauge and off color, nothing right. And I urged them to work with the vendors and to work on instrumentation. A lot of what I urged them to do came very naturally to the Japanese, though they were not doing it. I said, 'You don't need to receive the junk that comes in. You can never produce quality with that stuff. But with process controls that your engineers are learning about, specifications as loose as possible, consumer research, redesign of products, you can. Don't just make it and try to sell it. But redesign it and then again bring the process under control. The cycle goes on and on continually, with ever increasing quality.'

"I knew the problems because I'd been at Aberdeen Proving Ground, working there for the War Department, with people in industry. And look at the Census Bureau. It was one of the largest organizations to be immersed in quality.

"One of the big problems of management is to define quality and realize that there are several facets. One is what you're trying to do for the future, whatever quality you're aiming at. Should your purchasing agent continue to buy this kind of paint, or should he switch? But also, how about turning out product today? What is the plant manager's job today?

"Now only the management can work on that problem of defining quality. It's a complicated problem with no easy solutions, but it's management's responsibility.

"I tried to explain these things to them, and apparently they

understood. They wanted more conferences, so we had more. It was a terrifying experience for me because I was new at it. I was a technical man.

"I told them they would capture markets the world over within 5 years. They beat that prediction. Within 4 years buyers all over the world were screaming for Japanese products.

"I was back in Japan in 6 months, in Janury of 1951. They already had had many brilliant successes, brilliant fires, just as they had had here during the war. But that's not quality; those are just dividends. The top management showed me what they were doing. Mr. Nishimura, President of the Furukawa Electric Company, was himself working to evaluate the process that produced insulated wire. He brought control charts to show me, and he was able to reduce the amount of rework to 10% of what it had been.

Mr. Tanabe, President of the Tanabe Pharmaceutical Company, was working himself in quality control. In a few months he was producing 3 times as much para aminosalyscilic acid as before, with the same machinery, by just improving the system.

"But you cannot improve the system until you've achieved statistical control. Then engineers and chemists can see that it will stay this way until they make some changes.

"Now six months later here were these members of top management showing me what they had done. Six months after that trip, I was there again, and a year later there again. They were working hard, and they were getting results. I made it clear to them in those first

conferences that this must be company wide. 'Everybody in the company has a job to do to improve quality. And as you improve quality, your productivity will go up. Your customers will be happy, and you'll have something to sell.'

"I also told them 'This movement must be nationwide. You must teach other companies, teach your competitors, move along together. As you learn, tell others.' I didn't have to tell them that. That was the natural Japanese way of working But I did tell them anyway.

"By the time I'd made several trips to Japan, Juse was able to teach hundreds of people. They had courses for people outside of Tokyo in the daytime and courses in Tokyo in the evening for people who were working there during the day. There were also courses for management. They trained almost 20,000 engineers in rudimentary statistical methods within 10 years. These courses today are booked up seven months ahead.

Clearly, the Japanese appreciate what Ed Deming and statistical quality control have done to change their destiny. The MAINICHI DAILY NEWS describes the history of the Deming Prize, which symbolizes this appreciation.

"The Deming Prize was created in 1951 by the Union of Japanese Scientists and Engineers (JUSE) to commemorate the friendship and contribution of Dr. Deming to the whole spectrum of Japanese industry. The prize has played a significant role to give an impetus to industry in its dazzling growth.

"The Deming Prize is a silver medal. Designed by Professor

Kiyoshi Unno of Tokyo University of Fine Arts and some other artists, the medal bears an engraved profile of Dr. Deming.

"The Deming Prize is divided into three categories. The prize for research and education is awarded to those who made excellent researches in theory and application of quality control. Another prize for application is given to corporations or plants which attained outstanding results in practicing quality control. The third prize is provided for smaller enterprises.

"The prize has been awarded annually ever since 1951. The Deming Prize Committee is responsible for the selection of the winners from among a number of candidates. Parallel with the progress in Japan in the concept of quality control, the selection standard has been rising year after year, and the race for the laurels has become keen. It is said that most corporate candidates are spending years in streamlining and reinforcing their quality control setup under the guidance of specially invited experts before they apply for the prize."

Business Week, on page 21 of a special advertising section on "Japan: Quality Control and Innovation" of July 20, 1981, lists the winners of the Deming Prize for Application for the years 1954 through 1980 and discusses its impact.

"Each year the competition grows in intensity, as more and more companies volunteer to undergo the close scrutiny required. For the firm that wins the Prize, and those that gain one of the associated awards, however, the rewards are significant, in profits as well as prestige. For other companies, the ceremony is a time for self-reckoning. The innovations in quality-control honored in any year usually soon become national norms."